



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

The Right Radar Backup for ADS-B

*Choices for a Safe Cost-Effective
Surveillance Architecture*

5 May 2005

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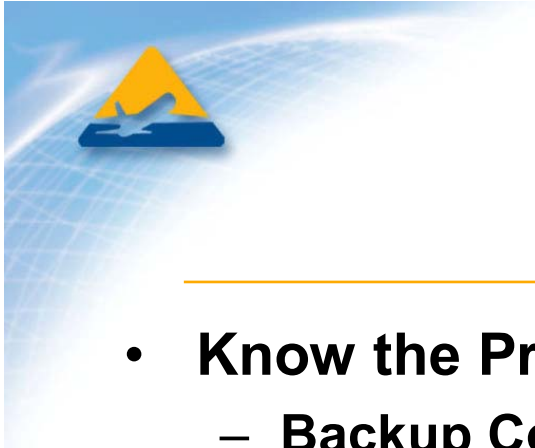
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Outline

- **Know the Problem**
 - Backup Concept
 - ADS-B Backup
 - Outage Description
- **Develop a Backup Architecture**
 - Requirement
 - Strategy
 - Technologies to Use
 - Backup Choices
- **Summary**
- **Appendix**
 - Radar Backup Coverage Examples



Surveillance Backup Today

- **Radar system component redundancy**
- **Overlapping coverage**
 - Redundancy volumes
 - Radar mosaic (select from 4 adapted sources)
 - Switch to alternate radar (typical TRACON operation)
 - Unique coverage volumes persist
- **Radar outage volume (backup same as no coverage)**
 - Aircraft retain navigation and communication
 - Non-radar procedures
 - Continue per clearance
 - Voice reports: position, identification, altitude
- **Individual aircraft transponder failures**
 - Primary radar or procedural backup

Backup—A reserve or substitute

Outage—A temporary suspension of operation



ADS-B

- **Digital surveillance data broadcast by radio**
 - GPS position, identification, barometric altitude, velocity
 - Ground-based receiver with telecommunication to ATC
 - Air-to-air surveillance (requires airborne receiver & CDTI)
- **Applications**
 - **Substitute for secondary surveillance radar (SSR)**
 - **Expand surveillance coverage (improve ATC services)**
 - Non-radar airspace & Airport surface
 - **Improve ATC operations**
 - Improve decision support automation
 - Reduce separation standard
 - **Improve aircraft operations & situation awareness**
 - Cockpit display of traffic information (CDTI)
 - Enhanced see and avoid
 - Future ATC concepts (e.g., Controller-Assigned Airborne Separation)



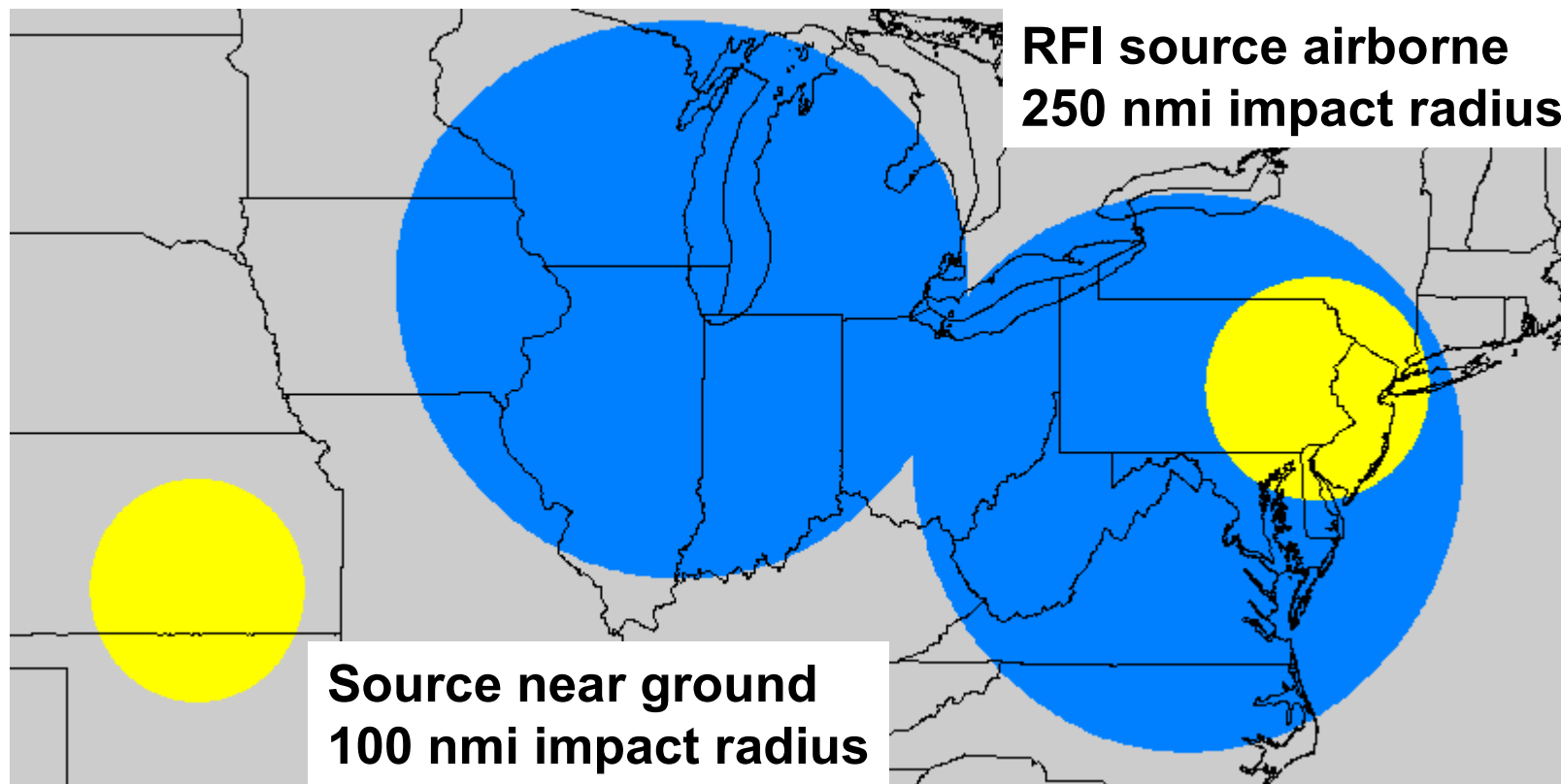
ADS-B Backup

- **Same approach as radar**
 - System component and coverage redundancy
 - Non-surveillance procedures
 - For avionics outage (1 aircraft)
 - For coverage volume outage
- **Backup modes for GPS outage**
 - Backup nav
 - FAA plans for DME, VOR, ILS
 - Backup nav input to ADS-B = ADS-B business as usual
 - No nav for ADS-B = ADS-B outage; requires backup by
 - Surveillance radar
 - Procedures



GPS Outage

- Very rare, unpredictable
- RFI most likely cause—localized impact



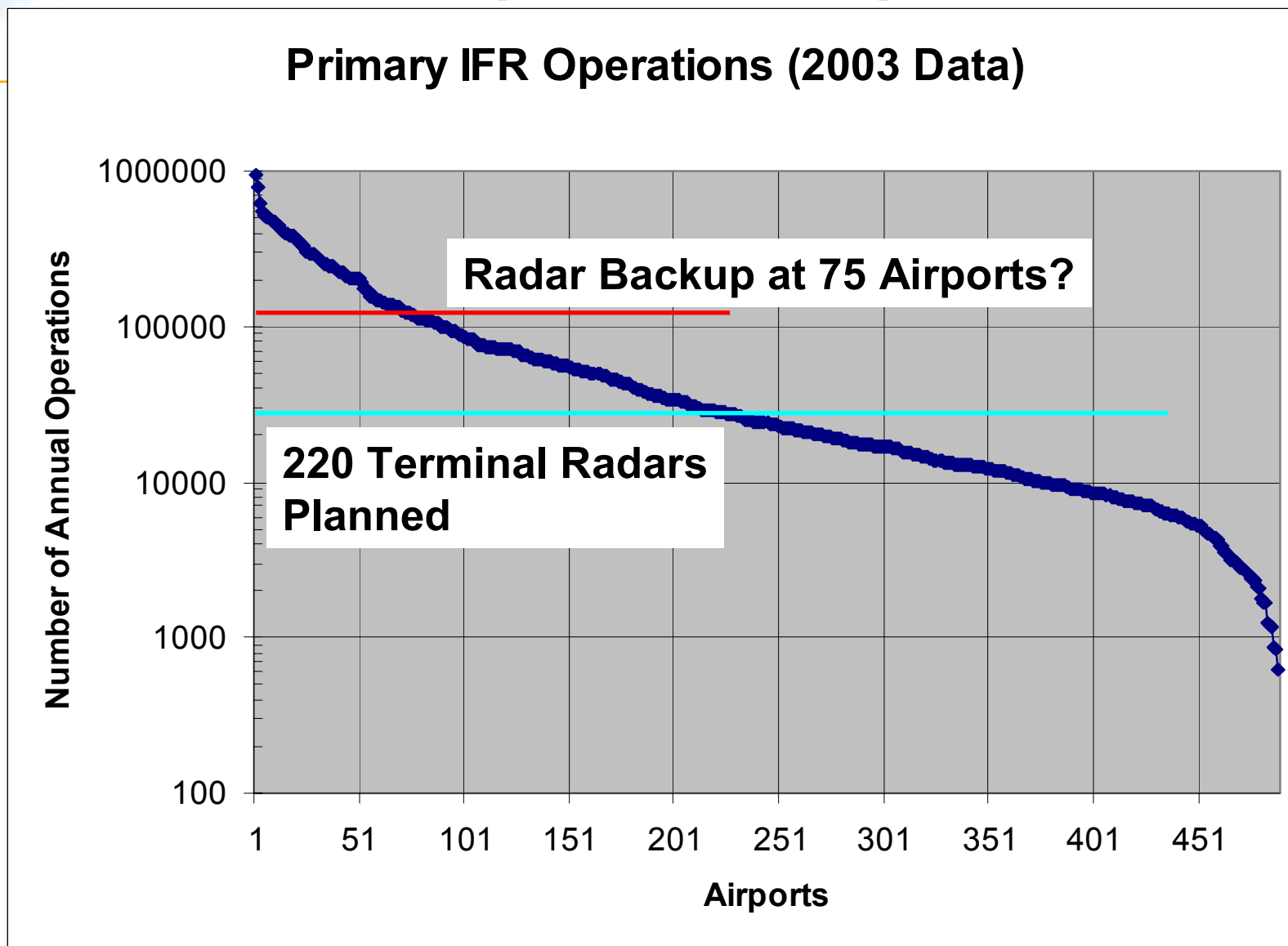


Surveillance Backup Requirement Plan for Large Area ADS-B Outage

- **Surveillance needed to sustain high-load airspace capacity**
 - Potentially many aircraft en route
 - NAS must enable all to reach destinations or alternates
- **Simultaneous capacity loss at many airports unacceptable**
 - Backup high-capacity airports
 - Analysis required to assess extent to provide radar backup at medium-capacity airports
 - Factors to weigh: IFR operations data, geographic proximity of alternates



What is Acceptable Backup Threshold?





Strategy to Choose Backup for ADS-B Outage

- **Consider infrastructure resources and available technologies to apply**
- **Evaluate airspace for cost-effective choices**
 - ATC mission & operations requirement focus
 - Segment airspace by class and location
 - Consider traffic volume
 - Consider rulemaking (e.g., ADS-B backup nav required)
- **Compare FAA backup with homeland security needs**
 - Adapt FAA selection
 - Use available security radars to assist
 - Negotiate cost share MOA with other agencies
 - FAA-only backup as basis for negotiation



Technologies to Minimize Costs and Optimize Performance

- **Consolidate resources**
 - All radars available for any terminal or en route ATC sector
 - Post 9/11 ATC requirement
 - Use FAA & DOD terminal (43 to ~90 DoD) and en route radars
 - Use technology to share information
- **Operate terminal radars at technical range limits**
 - Reduce total number of radars needed
- **Reduce radar subsystem redundancy**
 - Lower purchase and maintenance costs
 - Is single channel availability sufficient for backup?
- **Improve NAS operation in backup radar mode**
 - Upgrade antiquated mosaic display mode
 - Extend 3 nmi separation limit to 120 nmi
 - New MSSR 120 nmi accuracy = old SSR at 40 nmi

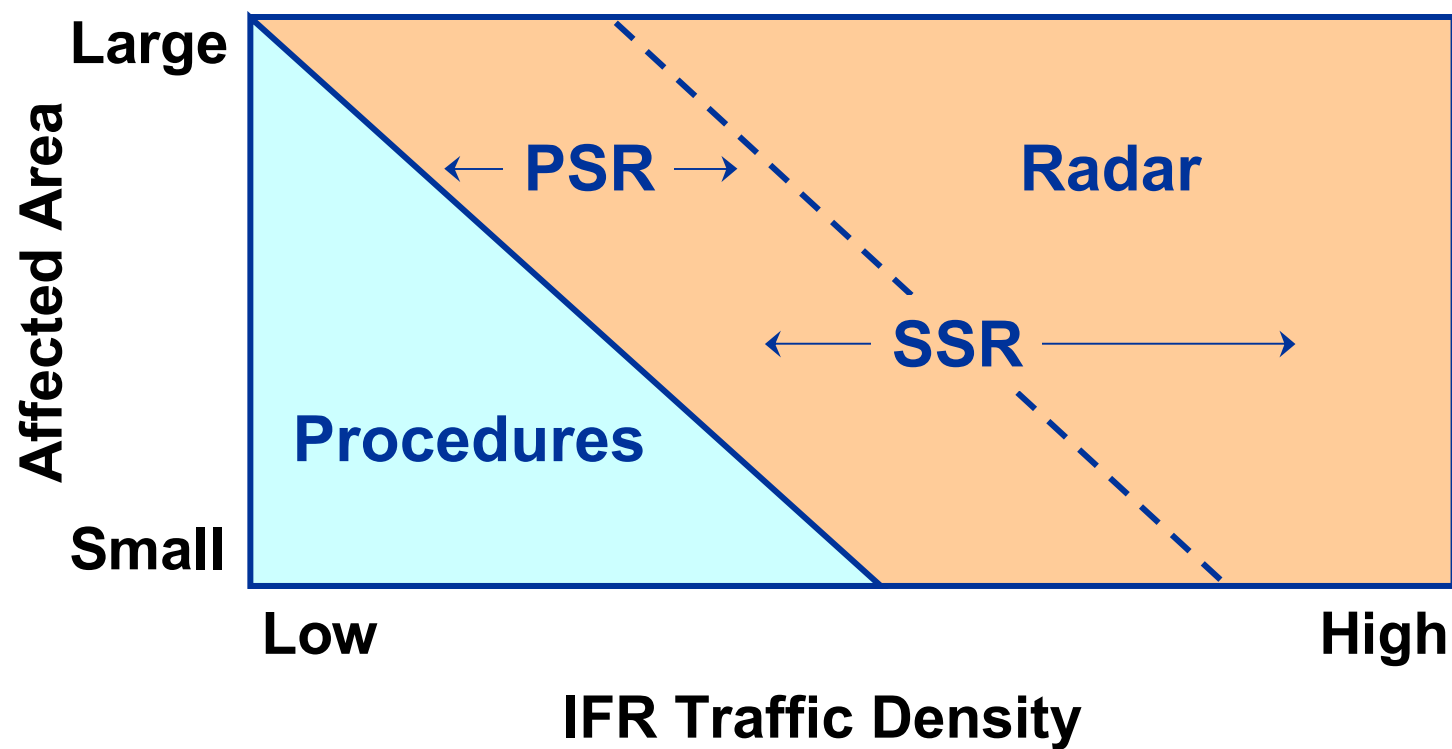


Radar Characteristics for Surveillance Backup

- **Primary surveillance radar (PSR)**
 - Uncooperative air vehicles & failed transponders
 - Radar identification and altitude reporting procedures
 - Manually-assisted automated tracking
 - Supports low traffic volume at high ATC workload
- **Secondary surveillance radar (SSR)**
 - Cooperative avionics
 - Identification and altitude (Modes A & C)
 - Few manual inputs needed to sustain air situation display
 - Supports high traffic volume at lower ATC workload

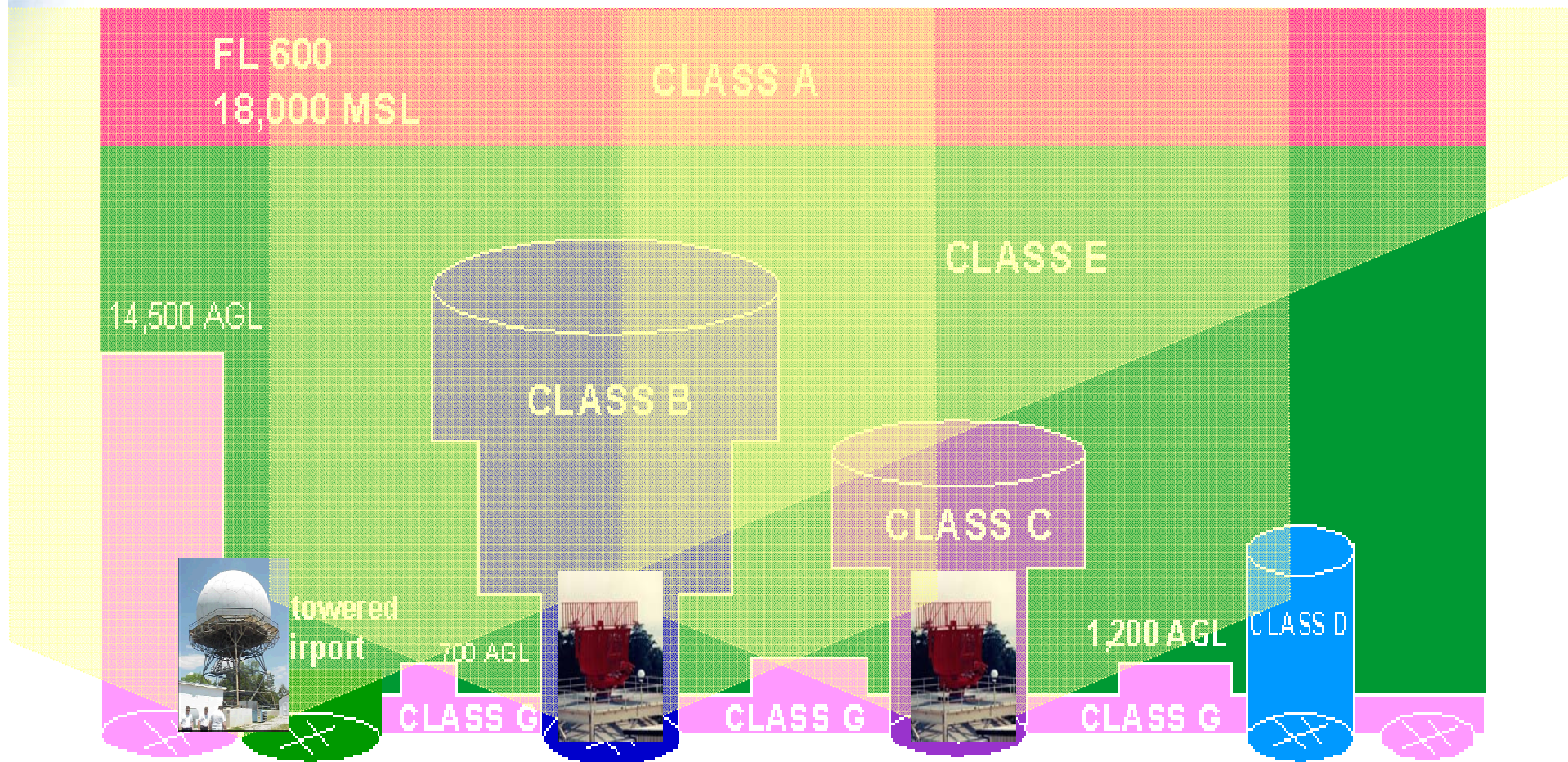


ADS-B Outage Backup Choices





Airspace Classifications





What Specific Airspace to Backup?

- **Benefit vs. cost analysis per airspace segment**
- **Pick a threshold for Class B & C (airport) backup**
 - 50 airports > ~550 IFR ops/day (46/hr—12 hr avg)
 - 75 airports > ~330 IFR ops/day (27/hr—12 hr avg)
- **Class A airspace scenarios**
 - Cover it all
 - No radar in low-traffic airspace (e.g., MT, ID, WY, ND, SD)
 - No radar backup (nav backup required for ADS-B)
- **Class D & E airspace scenarios**
 - Fill-in to cover specified areas > 6,000 ft AGL
 - No backup for low-traffic airspace



Summary: To Choose a Safe Cost-Effective Surveillance Architecture

- **Avoid surveillance loss for high-traffic airspace**
- **Avoid surveillance loss for high-capacity airports**
- **Choose backup for large area GPS outage**
 - **Analyze requirements**
 - **Assemble technology alternatives**
 - **Evaluate airspace segments by class & location for backup**
 - **Select from rulemaking, SSR, procedures**
- **Compare FAA backup with security radar needs**
 - **Adapt plan to use available radars**
 - **Negotiate cost share**

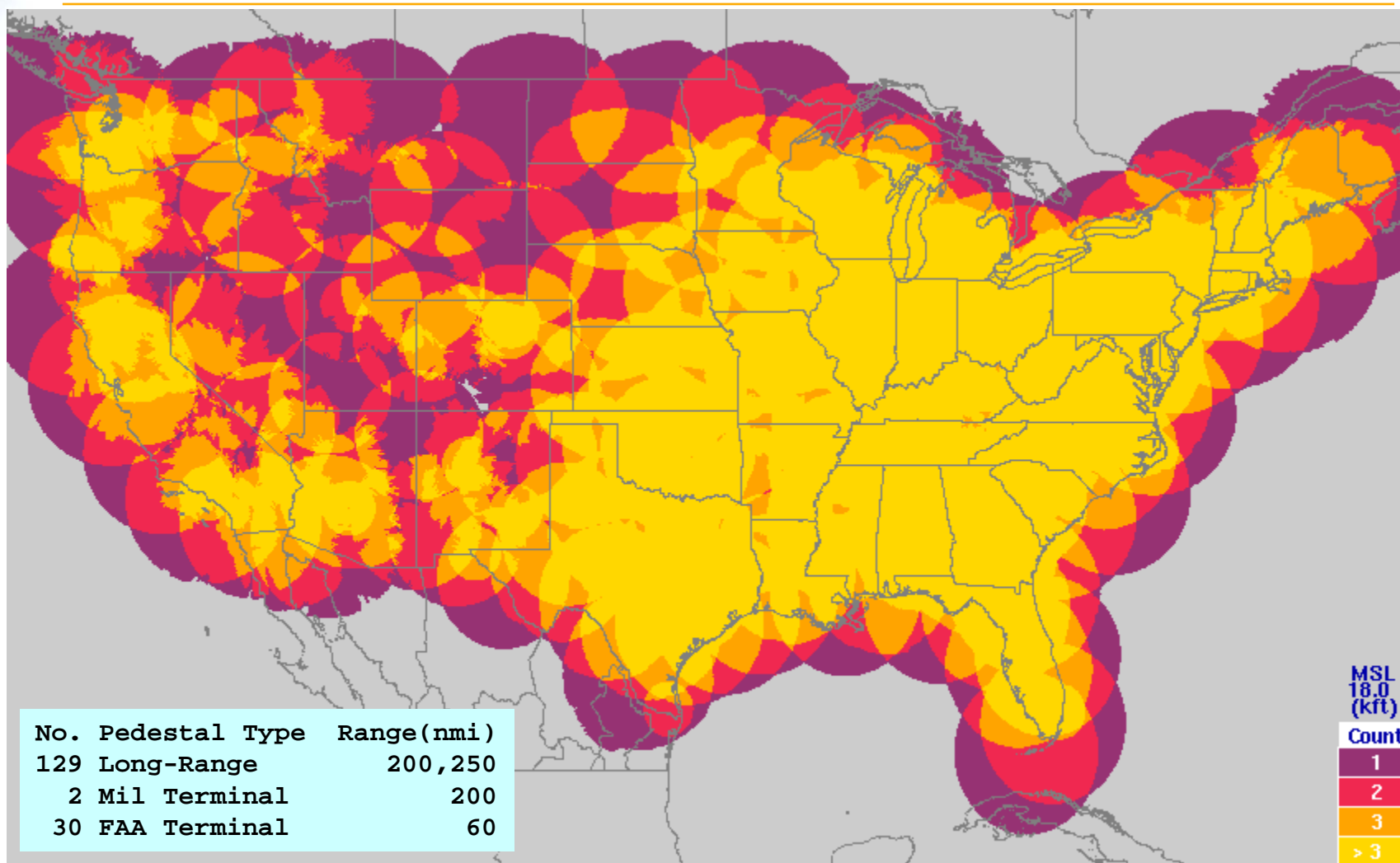


Questions



Radar Coverage Redundancy Today

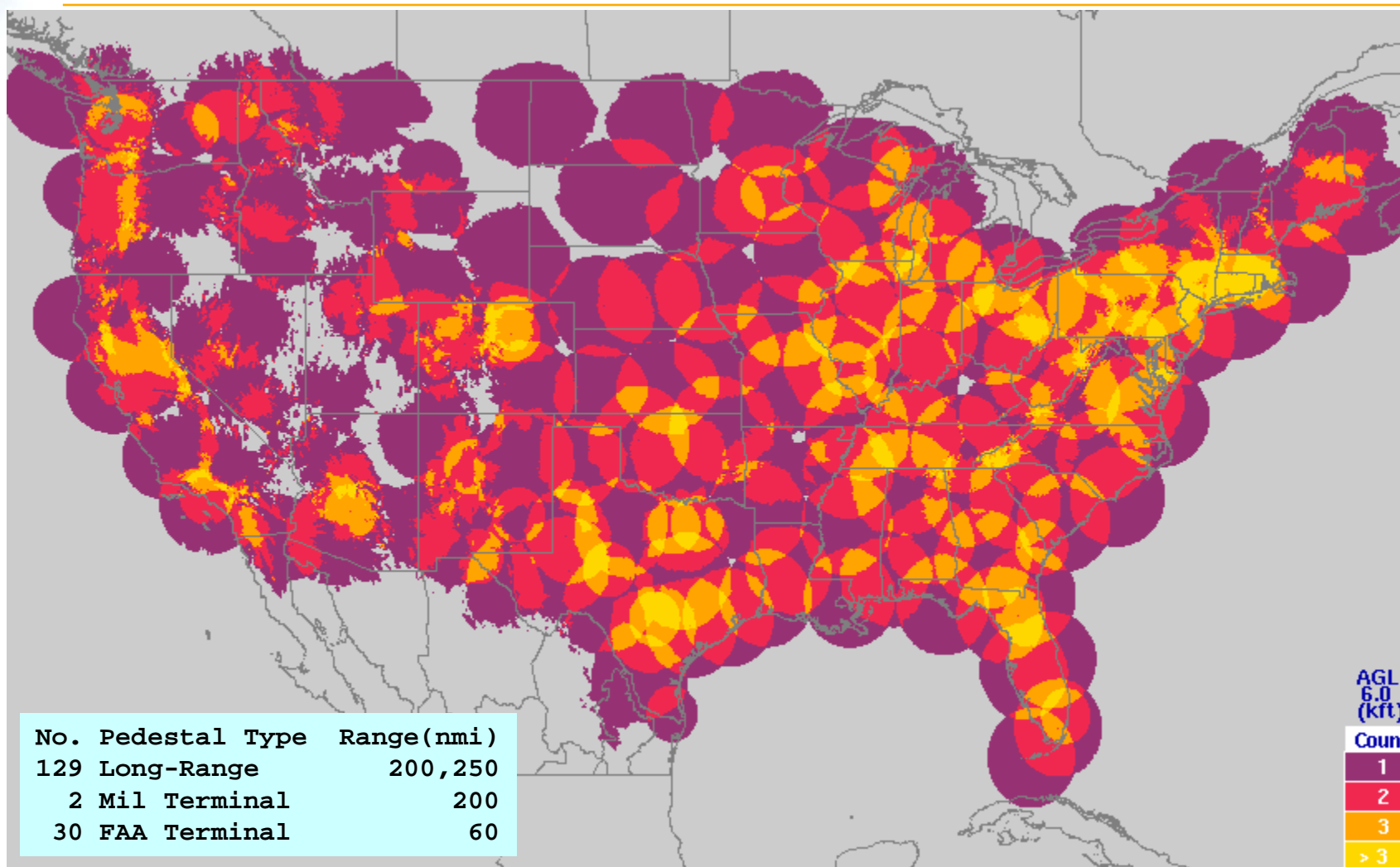
ARTCCs 18,000 ft MSL





Radar Coverage Redundancy Today

ARTCCs 6,000 ft AGL





FAA Mission Backup Radar Example

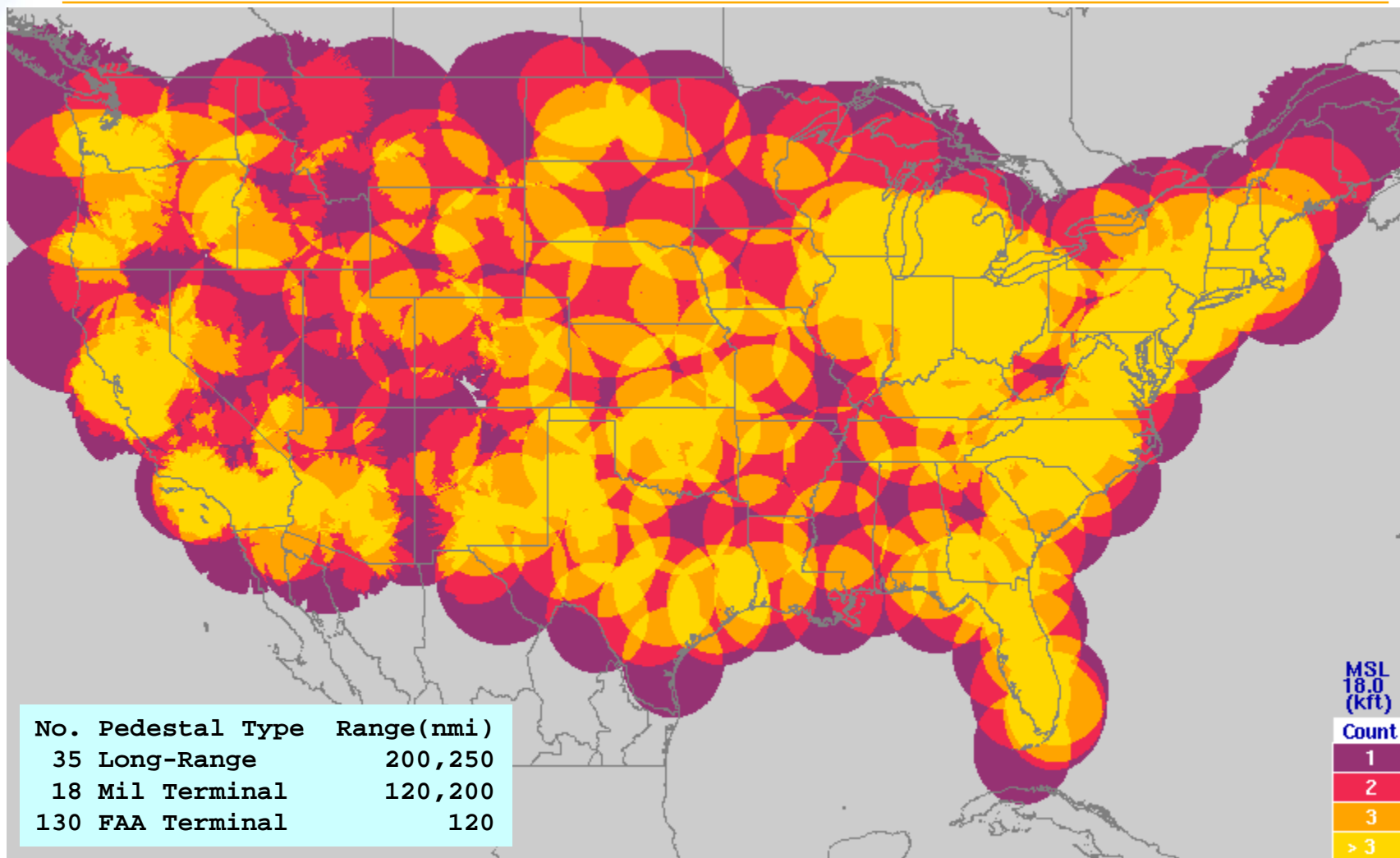
- Sites selected for FAA mission
- 183 SSR-only sites = 35 long-range + 148 terminal
- SSR at top 100 IFR ops terminals
- En route coverage = approx. NAS today > 6,000 ft AGL
- 18 terminal locations (of 43 available) are DoD radars
 - Used for NAS IFR tower en route operation
- Range extended terminal radar (120 nmi)

No.	Pedestal Type	Range(nmi)
35	Long-Range	200,250
18	Mil Terminal	120,200
130	FAA Terminal	120



Backup Radar Coverage Example

FAA Mission-Only 183 SSR 18,000 ft MSL

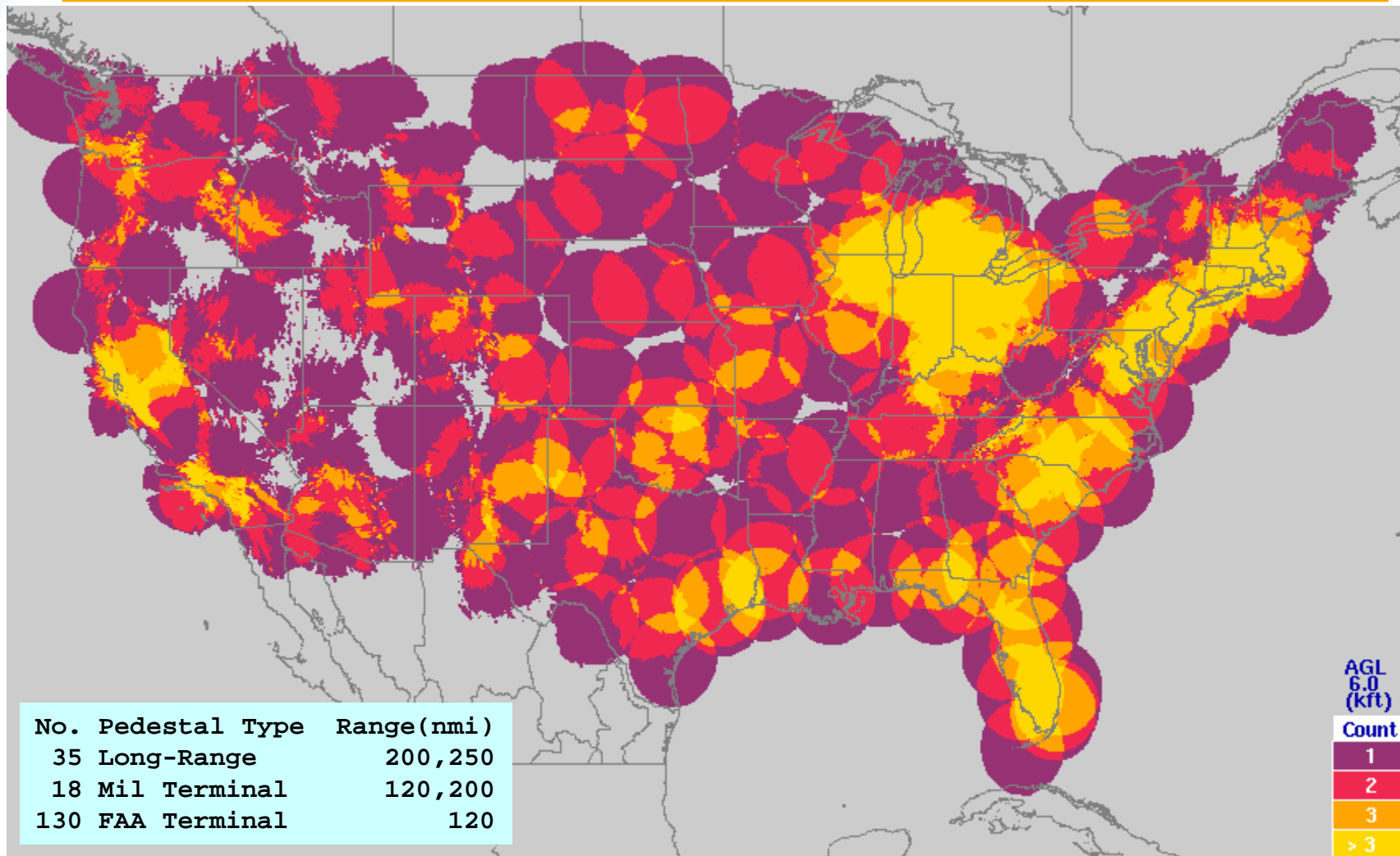


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Backup Radar Coverage Example

FAA Mission-Only 183 SSR 6,000 ft AGL





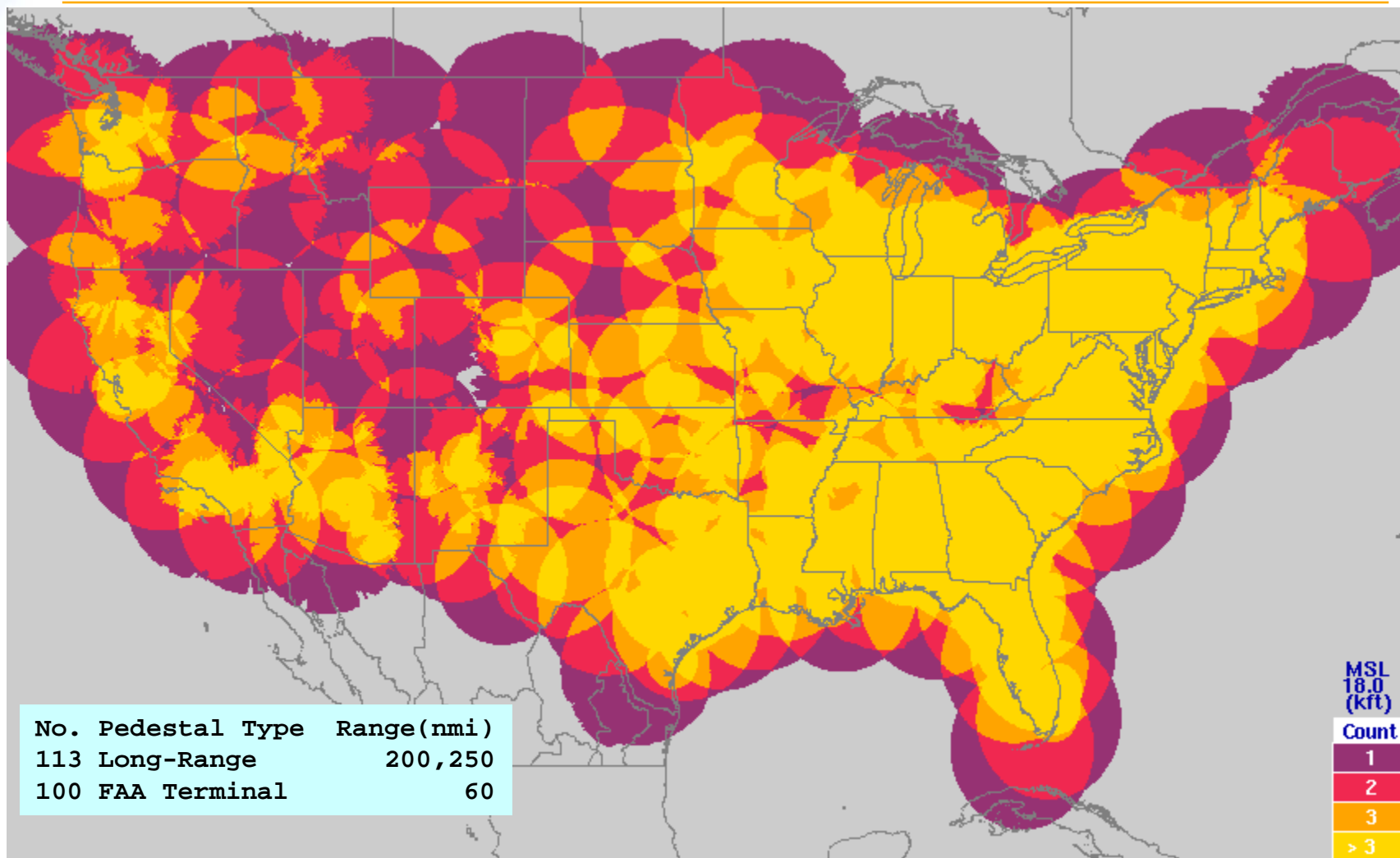
Combined Mission Backup Radar Coverage Example

- **FAA backup coverage using shared homeland security radars**
- **213 sites = 113 long-range + 100 terminal**
- **SSR at all long-range PSR sites (homeland security sites)**
- **SSR at 100 IFR ops terminals**

No.	Pedestal Type	Range(nmi)
113	Long-Range	200,250
100	FAA Terminal	60

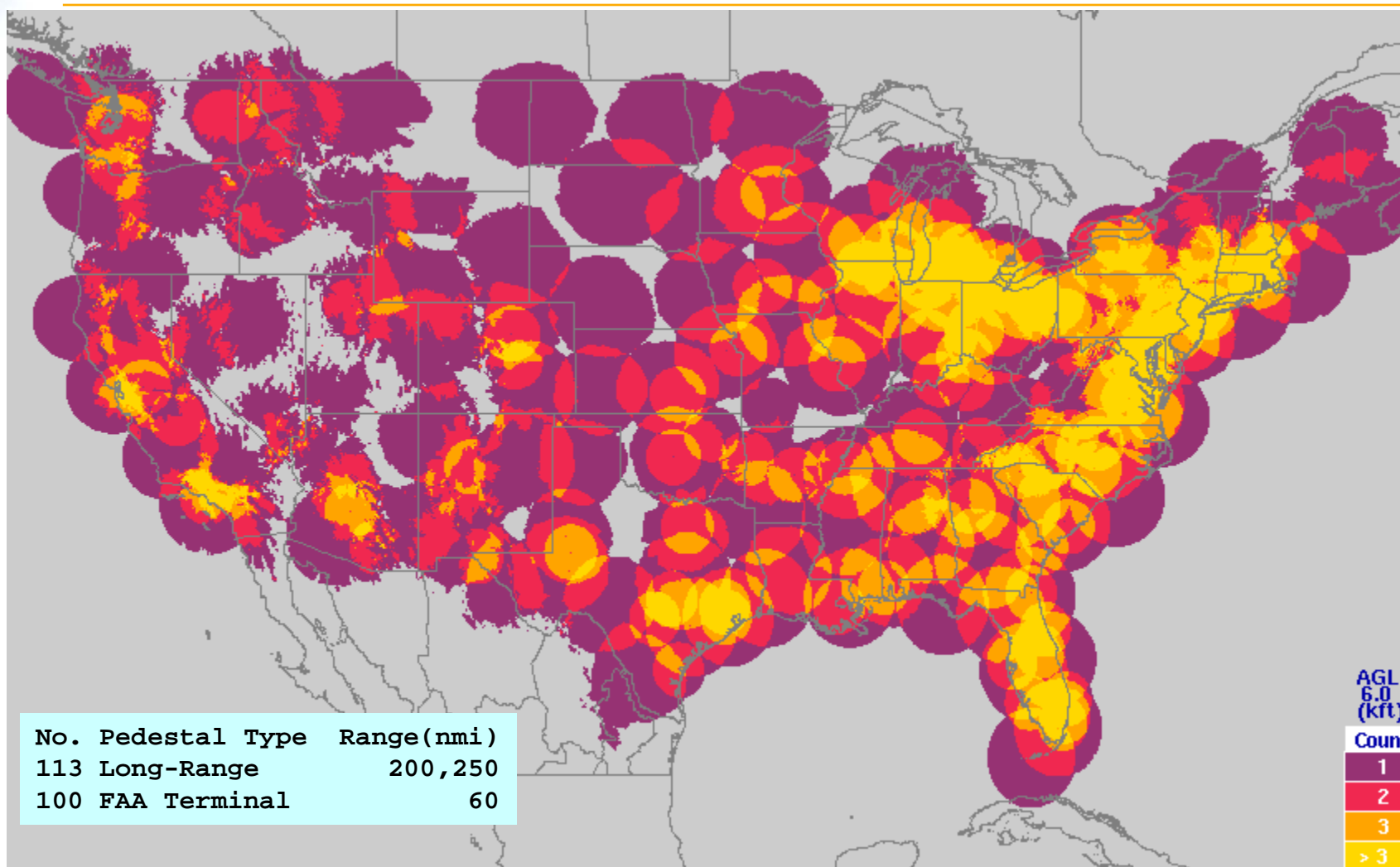


Backup Radar Coverage Example FAA & Shared Sites at 18,000 ft MSL





Backup Radar Coverage Example FAA & Shared Sites at 6,000 ft AGL





Strategies to Select Radar Sites

- **Airports then en route**
 - Add top IFR traffic airports
 - Add more airports to fill Class A gaps
 - Add en route sites to complete Class A
 - Add airports to fill desirable Class E
- **En route then airports**
 - Share with homeland security requirement
 - Variant 1: no SSR for low-traffic Class A
 - Variant 2: minimize redundancy in Class A
 - Add top IFR traffic airports
 - Add to gap fill high-traffic Class E
- **Evaluate benefit vs cost for each increment**

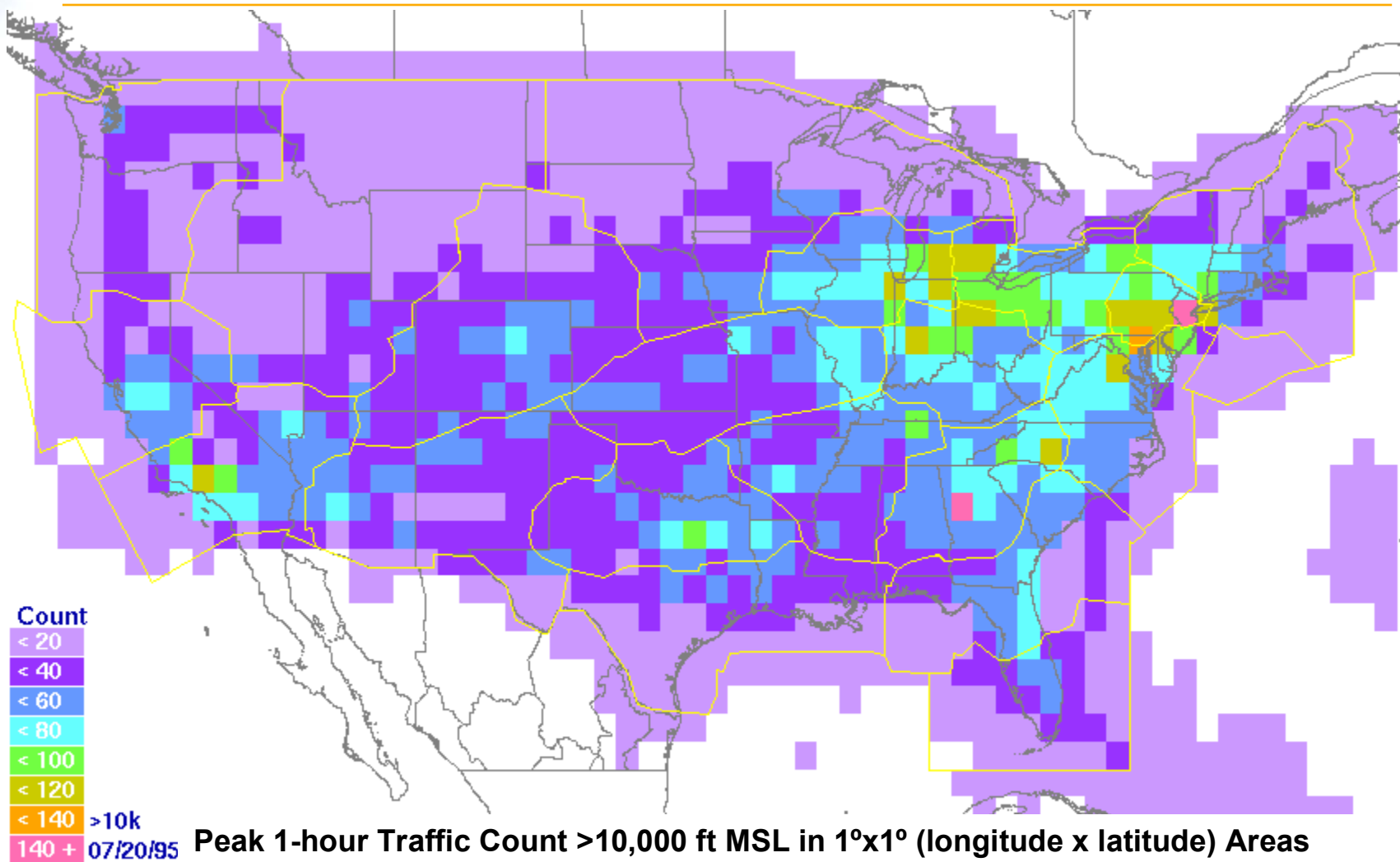


Homeland Security and Law Enforcement Radar Needs

- **PSR requirement**
 - Detection and tracking of non-cooperative aircraft
 - In current use
 - All CONUS long-range radars
 - Selected terminal radars
- **SSR requirement**
 - Essential for sorting
 - SSR backup for ADS-B outage requirements likely to differ for HLS & LE missions
 - Supports DoD IFF function



En Route Traffic Peak Hour Count





Range Extend Terminal SSR

- **Operate terminal SSR at full range capability**
 - Extend coverage further into Class A & E airspace
 - Reduce total radars required
- **ASR-11 MSSR 120 nmi instrumented range**
 - Site selectable
- **Terminal Mode S 150 nmi instrumented range**
 - WJHTC 1996-97 tests
 - Software adaptation
 - Many currently operating at 100 nmi



Terminal MSSR Range Extension

